

What is claimed is:

1. A multi-lumen catheter comprising:

(a) a central, elongated, multi-lumen tube portion having a proximal end and a distal end, the central tube portion having a substantially cylindrical outer shape and being internally segmented into a plurality of lumens;

(b) a distal branch portion comprising a plurality of single-lumen distal extension tubes, each distal extension tube having a proximal first end and a distal second end, the proximal first end of each distal extension tube being permanently connected to the distal end of the central tube portion such that the single lumen of each distal extension tube is in fluid communication with one of the plurality of lumens of the central tube portion;

(c) a proximal branch portion comprising a plurality of single-lumen proximal extension tubes, each proximal extension tube having a distal first end and a proximal second end, the distal first end of each proximal extension tube being permanently connected to the proximal end of the central tube portion such that the single lumen of each distal extension tube is in fluid communication with one of the plurality of lumens of the central tube portion; and

(d) a plurality of selectively attachable connector hubs, each connector hub being configured to be selectively attachable to the distal second end of one of the distal extension and being configured for selective connection to a fluid exchange device;

wherein each lumen of the central tube portion and the lumens of the distal and proximal extension tubes in fluid communication therewith define a flow path through the catheter.

2. A multi-lumen catheter according to Claim 1, wherein the central tube portion includes two lumens, the distal branch portion includes two distal extension tubes, and the proximal branch portion includes two proximal extension tubes.
- 5 3. A multi-lumen catheter according to claim 1 wherein the plurality of single-lumen distal extension tubes of the distal branch portion converge to form a distal multi-lumen connecting portion which connects to the distal end of the central tube portion, and the plurality of single-lumen proximal extension tubes comprising the proximal branch portion converge to form a proximal multi-lumen connecting portion which connects to the proximal end of the central tube
10 portion.
4. A multi-lumen catheter according to claim 1 wherein the central tube portion, the distal extension tubes, and the proximal extension tubes are comprised of a fusible material, and the distal extension tubes and proximal extension tubes are respectively fused to the distal and
15 proximal ends of the central tube portion.
5. A multi-lumen catheter according to claim 1 wherein the distal extension tubes have a substantially cylindrical outer shape near their distal second ends.
- 20 6. A multi-lumen catheter according to claim 3 wherein the proximal extension tubes have a substantially D-shaped cross-section over at least a portion of their length.

7. A multi-lumen catheter according to claim 3 wherein the proximal multi-lumen connecting portion has a substantially cylindrical outer shape.
8. A multi-lumen catheter according to claim 1 wherein the proximal extension tubes are substantially parallel to each other in a free state.
9. A multi-lumen catheter according to claim 1 wherein the at least one of the proximal extension tubes is shorter in length than at least one other proximal extension tube.
10. A multi-lumen catheter according to claim 1 further including a stabilizing cuff affixed to an outer portion of the central tube portion.
11. A multi-lumen catheter according to claim 1 wherein the proximal end of each selectively attachable connector hub includes a tube portion configured to be sealably inserted into a portion of a lumen at the distal second end of one of the distal extension tubes.
12. A multi-lumen catheter according to claim 11 wherein the tube portion of each connector hub includes at least one outer circumferential step, barb, or ridge for releasably gripping a portion of a distal extension tube into which the tube portion is inserted.
13. A multi-lumen catheter according to claim 1, wherein each of the proximal extension tubes includes a tube wall, and each of the proximal extension tubes includes at least one opening extending through its tube wall.

14. A multi-lumen catheter according to claim 1, wherein an external portion of at least one of the distal extension tubes includes indicia, the indicia indicating a discrete flow path through the catheter.

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15. A multi-lumen catheter according to claim 2 wherein the two proximal extension tubes have longitudinal axes which intersect at an included angle in a free state, the included angle being in a range from about 10 degrees to about 30 degrees.

10 16. A y-shaped catheter junction comprising:

(a) a dual-lumen trunk having a substantially cylindrical outer wall, a first end, a second end, a first lumen, and a second lumen;

(b) a first single-lumen extension tube connected to the first end of the trunk, wherein the single lumen of the first single-lumen extension tube is in fluid communication with the first lumen of the trunk; and

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(c) a second single-lumen extension tube connected to the first end of the trunk, wherein the single lumen of the second single-lumen extension tube is in fluid communication with the second lumen of the trunk;

wherein the first lumen of the trunk and the first extension tube define a first flow path,

20 and the second lumen of the trunk and the second extension tube define a second flow path.

17. A y-shaped catheter junction according to claim 16 wherein the first and second extension tubes have longitudinal axes which intersect at an included angle near a first end of the

trunk in a free state, the included angle being in a range from about 10 degrees to about 30 degrees.

18. A method of forming a multi-lumen catheter, the method comprising permanently
5 attaching a first plurality of single-lumen extension tubes to a distal end of a length of multi-lumen tubing comprising a plurality of multiple lumens, and permanently attaching a second plurality of single-lumen extension tubes to a distal end of the length of multi-lumen tubing, wherein each single lumen of each extension tube is in fluid communication with one of the lumens of the length of multi-lumen tubing.

10 19. A method according to Claim 18, wherein the length of multi-lumen tubing includes two lumens, and the first and second pluralities of extension tubes form substantially y-shaped junctions on each end of the length of multi-lumen tubing.

15 20. A method of forming a multi-lumen catheter according to Claim 19, the method comprising:

(a) forming a y-shaped distal junction including:

(i) providing a first length of single-lumen tubing to form a distal arterial extension tube;

20 (ii) providing a second length of single-lumen tubing to form a distal venal extension tube;

(iii) providing a first length of multi-lumen tubing comprising at least an arterial lumen and a venal lumen, and having a distal end and a proximal end;

(iv) permanently attaching an end of the distal arterial extension tube to the distal end of the first length of multi-lumen tubing such that the distal arterial extension tube is in fluid communication with the arterial lumen of the first length of multi-lumen tubing; and

5 (v) permanently attaching an end of the distal venal extension tube to the distal end of the first length of multi-lumen tubing such that the distal venal extension tube is in fluid communication with the venal lumen of the first length of multi-lumen tubing;

10 wherein the proximal end of the first length of multi-lumen tubing forms a connecting end;

(b) providing a second length of multi-lumen tubing having a distal end and a proximal end, and having an arterial lumen and a venal lumen, and permanently attaching the connecting end to the distal end of the second length of multi-lumen tubing, such that the arterial extension tube of the distal junction is in fluid communication with the arterial lumen of the second length of multi-lumen tubing, and the venal extension tube of the distal junction is in fluid communication with the venal lumen of the second length of multi-lumen tubing;

(c) forming a y-shaped proximal junction including:

20 (i) providing a third length of single-lumen tubing to form a proximal arterial extension tube;

(ii) providing a fourth length of single-lumen tubing to form a proximal venal extension tube;

(iii) providing a third length of multi-lumen tubing comprising at least an

arterial lumen and a venal lumen, and having a distal end and a proximal end;

(iv) permanently attaching an end of the proximal arterial extension tube to the distal end of the third length of multi-lumen tubing such that the proximal arterial extension tube is in fluid communication with the arterial lumen of the third

length of multi-lumen tubing; and

(v) permanently attaching an end of the proximal venal extension tube to the distal end of the third length of multi-lumen tubing such that the proximal venal extension tube is in fluid communication with the venal lumen of the third length of multi-lumen tubing;

wherein the distal end of the third length of multi-lumen tubing forms an attachment end; and

(d) permanently attaching the attachment end to the proximal end of the second length of multi-lumen tubing, such that the arterial extension tube of the proximal junction is in fluid communication with the arterial lumen of the second length of multi-lumen tubing, and the venal extension tube of the proximal junction is in fluid communication with the venal lumen of the second length of multi-lumen tubing;

21. A method according to claim 20, the method further comprising forming at least one opening in a wall of the proximal venal extension tube, and forming at least one opening in a wall of the arterial proximal extension tube.

22. A method according to claim 20 wherein permanently attaching extension tubes and

lengths of multi-lumen tubing together or to each other comprises fusing ends of the tubes or tubing together.

23. The method of claim 19, wherein the longitudinal axes of the distal arterial extension

5 tube and the distal venal extension tube intersect at an included angle in a free state, the included angle being in a range from about 10 degrees to about 30 degrees.

24. A method for surgically implanting a double-y shaped multi-lumen catheter tube into a patient, the multi-lumen catheter including an elongated, central, multi-lumen tube portion, a

10 proximal end portion including a single-lumen proximal venal extension tube and a single-lumen proximal arterial extension tube each having a proximal tip, and a distal end portion including a single-lumen distal venal extension tube and a single-lumen distal arterial extension tube each having a distal end, the method comprising:

(a) making an incision in the skin of the patient

15 (b) inserting the proximal tips of the proximal venal and arterial extension tubes through the incision and placing the proximal tips in the patient;

(c) forming a subcutaneous tunnel having a first end proximate to the incision and a second end remote from the first end of the tunnel;

(d) guiding the distal venal and arterial extension tubes and at least a portion of the
20 central tube portion through the subcutaneous tunnel such that at least the distal ends of the distal venal and arterial extension tubes extend outwardly from the tunnel through the second end of the tunnel; and

(e) securing at least a portion of the distal end portion of the catheter to the patient.

25. A method according to claim 24, the method further comprising respectively connecting the distal arterial and venal extension tubes to arterial and venal legs of a fluid exchange device.

5 26. A method according to claim 25, wherein connecting the distal arterial and venal extension tubes to arterial and venal legs of a fluid exchange device comprises connecting the distal arterial extension tube to the arterial leg with a first connector hub, and connecting the proximal venal extension tubes to the venal leg with a second connector hub.

10 26. The method of claim 23, wherein inserting the proximal tips of the proximal venal and arterial extension tubes into a patient comprises:

placing the proximal tip of the venal extension tube into a vein in the patient; and

placing the proximal tip of the arterial extension tube into an artery in the patient.

15 28. The method of claim 24 wherein the central tube portion further includes a stabilizing cuff affixed to an outer portion of the central tube portion, the method further comprising dilating at least a portion of the subcutaneous tunnel before guiding the distal venal and arterial extension tubes and at least a portion of the central tube portion through the subcutaneous tunnel, wherein the dilating step comprises sliding a sheath dilator along a shaft of a trocar
20 longitudinally positioned in the tunnel.

29. The method of claim 28 wherein securing at least a portion of the distal end portion of the catheter to the patient comprises seating the stabilizing cuff in a dilated portion of the

subcutaneous tunnel.

30. The method of claim 24 wherein guiding the distal venal and arterial extension tubes and at least a portion of the central tube portion through the subcutaneous tunnel comprises:

- 5 (a) inserting a trocar through the subcutaneous tunnel such that an insertion tip of the trocar protrudes from the first end of the tunnel;
- (b) connecting the distal ends of the distal venal and arterial extension tubes to a proximal end of a connector;
- (c) connecting a proximal end of the connector to the protruding insertion tip of the
10 trocar; and
- (d) guiding the distal venal and arterial extension tubes and at least a portion of the central tube portion through the subcutaneous tunnel with the trocar.

31. The method of claim 30 further comprising placing a sheath having a smooth outer
15 contour over the connector and at least portions of the venal and arterial extension tubes before guiding the distal venal and arterial extension tubes and at least a portion of the central tube portion through the subcutaneous tunnel with the trocar.